SNS RFQ Problem
Findings and Recommendations

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ORNL Participants

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Symptoms

- Off frequency 400-600 kHz low
  - 119 kHz vacuum-air correction
- Field peaks around module 3 (250 cm)
- Power couplers have incorrect fwd/rev pwr
  - Consequence of altered field profile
  - Coupler adjustment very critical
- Was able to run at high gradient at lower frequency

Symptoms - continued

- Was there an abuse from control system?
  - Ran for several hours in abnormal state
  - Temperature went down to 8C shown on archiver restart
  - Archiving data lost for critical period
- MPS system:
  - Can flow sensors not be sensed and not cut RF off at zero flow?

Materials

- RFQ is a Glidcop-OFHC sandwich
- Two brazes: material is fully annealed
  - No internal stresses in copper
  - Internal structure very soft
  - Glidcop still hard, all screw threads helicoiled
  - Very strong box structure

Temperature Excursions

- RFQ cooled to 8C
- Also ran at 19/24C temperature split
  - Large splits perfectly acceptable
  - Limited by chillers themselves
- Reran 8C Sunday
  - Thermal coefficient still 7kHz/C, okay

Possible Power Excursion

- Ran at 6% duty factor at LBL for long time
- Limited at 3% at ORNL
  - Hardware limit of pulse rate, length, power level
- Highly unlikely klystron went CW, as that would bring the whole system down quickly.

Full Gradient Operation

- With frequency (and field) error, the RFQ was run at full gradient
  - Indicates basically healthy cavity
  - Indicates that nothing has fallen across vanetips or stabilizers
  - Indicates no melted stalagmites of copper

Drive Loops

- All have continuity
- Measured Q_L with loops open/closed, terminated - Q measurements okay
- Must be very careful with windows
- Inspected loops 3A, 3C with borescope
- Pulled one loop for visual inspection
- Checked delta-F with external reactance
  - Pulled RFQ only 117 kHz
- Get some more 3-1/8” to N adaptors

Myat Power Divider

- Check out by Yoon
  - Pronounced okay
- LBL Tech Note 40 supplied on principle of operation of power divider
  - Definitely non-intuitive

Kink at Module 2-3 Junction?

- Observed that gap at junction is larger on bottom than on top
- This is not new: observed at LBL
- Vanetip alignment inspected with borescope
  - In good alignment
  - Slight step on inner wall okay

Vane Tip Movement

- Total wall movement sensitivity 43 MHz/mm
  - -2.3 MHz/mm outer wall only
  - ~+50 MHz/mm vane tip (all 4 together)
- For 20 cm long vane, about 1 mm motion required for 400 kHz shift
  - Should be quite evident
- For more extended region, too small to measure with tools used at present

Bending of RFQ?

- Could a large load be placed on middle?
  - Leaning on pump, e.g.
- This would run top/bottom vanes together
- But structure is very strong
- Find out if someone loaded RFQ
- Understand kinematic mounting structure

Glidcop-Copper Delamination

- Wall is ½ inch Glidcop bonded to copper
- Water cooling passages milled in interface
- Weakest area is around pump slots
- Measurements show no warping at slots
- Large area delamination would cause massive water leaks to outside
- Motion of outer wall only requires several cubic cm of copper to be removed for 400 kHz frequency shift

Endwall Tuners

- Entrance end
  - Demountable “cruciform mesa”
  - Removed, inspected, okay
  - Normal appearance
- Exit end
  - Much simpler geometry
  - Inspected with borescope, looked okay

Pi-mode Stabilizers

- Inspected from entrance end, looked okay
- Looked at in module 3 with borescope
- Even though annealed, still quite stiff
- To expand and bend enough to warp to short against vanes, would need to exceed temp diff of 600C - Virostek

Cleaning Vanetip Area

- Possibility of local short due to copper chip
  - Happened once during beadpull
- Pulled a cleaning “butterfly” whole length
- No significant change in frequency
- Found a very small copper bead sitting in radial matcher
- Nothing local responsible for 400 kHz shift

Bead Pull

- Use “butterfly” to do bead pull
  - 10 cm step, ~35 points, better resolution than 12 sense loops
  - Not complete agreement with sense loops
    - Fractional db difference, plausible explanation
- Should develop good bead pull system
  - Sending out adjustable endwalls

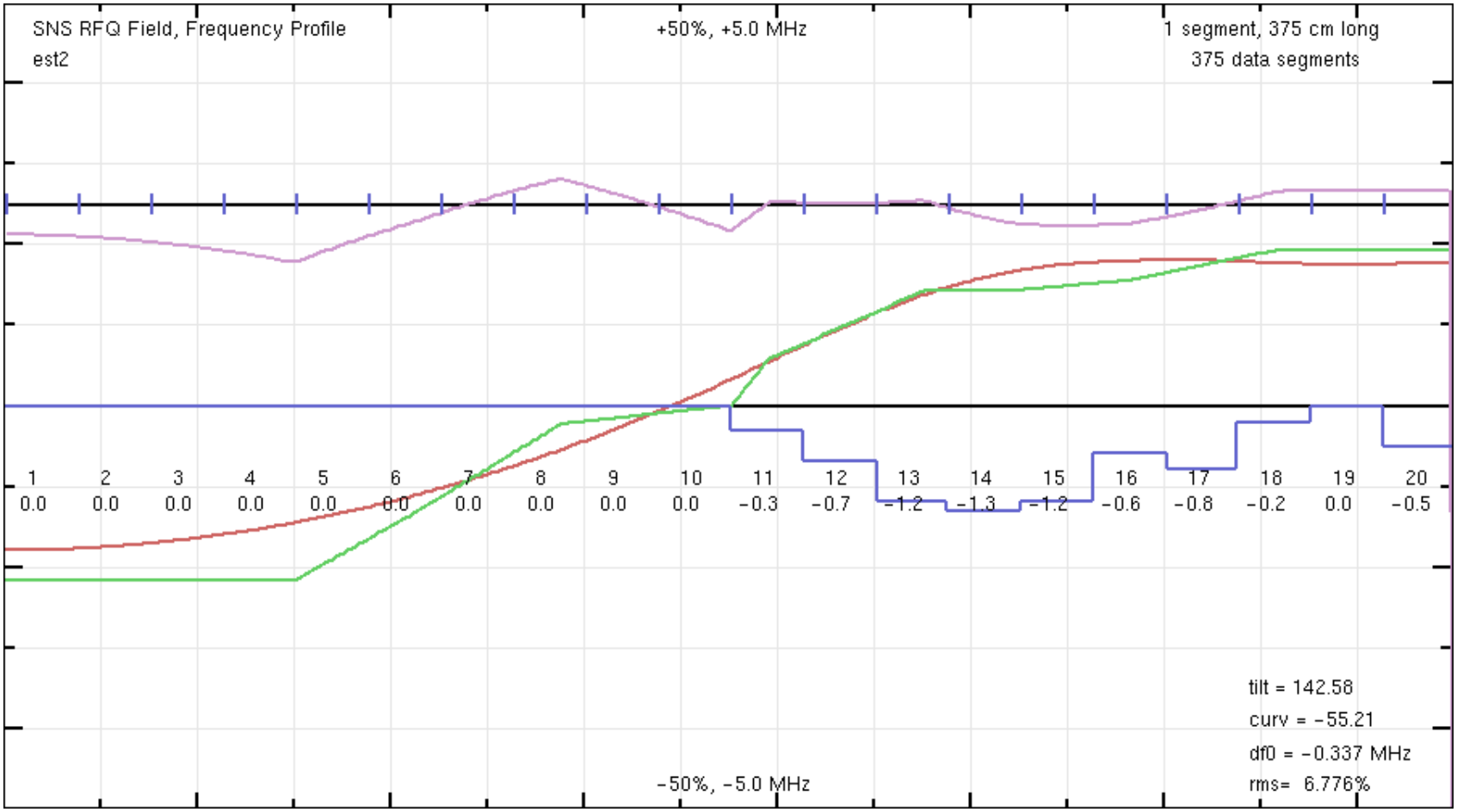
Remediation

- Still don’t know what happened during glitch
- Unable to do precise enough measurements of vane tip position
- Scans show problem centered in module 3
- All obvious candidates eliminated
- High-power operation already demonstrated

Remediation - continued

- Using scan data, calculate new tuner profile
  - Maximum tuner length change < 3 mm
  - About 1/3 of tuners need to be changed
  - Adjustable tuners arriving tomorrow
- ORNL people experts in tuning
- LBL people ready to come and help
- Beam dynamics will be revisited

RFQtune Program



Summary

- Still don’t know what happened
- Problem clearly in cavity itself
- Can’t measure vane positions to precision required – would have to disassemble
- No definitive archive data for clues
- Retune with tuners, should bring back to original field profile, frequency
- Investigate effect of small vanetip displacements on beam dynamics

Key LBL Contacts

- John Staples – physics, commissioning
- Steve Virostek – ME, thermal design
- Matt Hoff – Designer, brazing
- Alex Ratti – RF
- Don Syversrud – Vacuum, Installation
- Joe Wallig – Installation
- Larry Doolittle – LLRF
- Rod Keller – Support and alignment
- Bob Connor - CMM